Phase 2 Project Summary

Firm: Orbital Technologies Corporation
Contract Number: NNX11CB54C
Project Title: Advanced Carbothermal Electric Reactor

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

The primary purpose of the Phase 2 project was to develop and demonstrate an ACE Reactor Engineering Model to efficiently produce oxygen, iron and glass from simulated lunar regolith. The ACE Reactor Engineering Model was originally envisioned to be a small integrated carbothermal reduction processing system that included a carbon reduction reactor, gas clean-up bed, methanation reactor, water condenser, and potentially a water electrolysis unit to demonstrate all three steps of the carbothermal reduction process. The ACE Reactor Engineering Model was also intended to serve as a prototype of a carbothermal reduction payload for a robotic precursor mission. Unlike state-of-the-art carbothermal reactors that use concentrated solar energy and/or laser energy to heat the regolith, the ACE Reactor concept uses electric resistant elements to heat the regolith within a thermally insulated environment. The ACE Reactor concept eliminates the problems encountered with traditional carbothermal hot-wall reactors and offers significant advantages over state-of-the-art (SOA) carbothermal reactor approaches, including direct solar energy processing. By eliminating the need for a concentrated solar energy system, the ACE Reactor has the potential to significantly lowers system mass and removes the need to keep optical surfaces clean. The ACE Reactor approach can also produce the processed regolith in a form that can be directly used as a building or radiation shielding material.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

The overall objective of the Phase 2 effort was to develop and test an ACE Reactor Engineering Unit.

Task 1. Refine System Requirements
Task 2. Evaluate Improved Heating Methods
Task 3. Life Testing of the Crucible and Heating System
Task 4. Develop the Preliminary Design
Task 5. Perform Subsystem Testing
Task 6. Develop the Detailed Design
Task 7. Build the ACE Reactor Engineering Unit
Task 8. Develop the Control System
Task 9. Perform Check-Out Tests
Task 10. Laboratory Testing
Task 11. Delivery of the ACE Reactor Engineering Unit
Task 12. Project Management and Reporting

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

The preliminary system requirements for the ACE Reactor Engineering Unit were refined and review with the COTR and other NASA personnel at the Phase 2 kick-off meeting. Evaluation of alternative heating methods identified the preferred heating system for the ACE Reactor Engineering Unit. Life testing performed on the selected heating system and the crucible identified durability issues. The crucible was redesigned to avoid the problems encountered. The selected heating system was also modified to minimize the degradation issues observed during life testing. The design of the ACE Reactor Engineering Unit incorporates the knowledge gained during life testing of the heating system and processing crucible. An ACE Reactor Engineering Unit was built and tested near the end of the Phase 2 project before it was delivered to NASA. Further development is required to improve the durability of the heating system.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

The purpose of ISRU is to harness and utilize resources at the site of exploration to create products and services which can enable and significantly reduce the mass, cost, and risk of near-term and long-term space exploration. In particular, the ability to make propellants, life support consumables, fuel cell reagents, and radiation shielding can significantly reduce the cost, mass, and risk of sustained human activities beyond Earth. The ACE Reactor will meet this need by efficiently producing oxygen, metallic iron and glass from regolith. The oxygen produced could satisfy the needs of EVA, life support, and propulsion applications including orbital propellant depots. The metallic iron or silicate glass could be poured into molds to make building components, radiation shielding materials, or spare parts.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

The development of ACE reactor is clearly focused on supporting the needs of the NASA human exploration program. However, there are several commercial companies making significant progress towards spaceflight, including Bigelow Aerospace, Scaled Composites, and Space-X. There are significant cost/propulsive savings associated with obtaining oxygen from local regolith versus bringing it from Earth, and systems have been proposed to use lunar oxygen to resupply vehicles anywhere from LEO down to the lunar surface. As commercial flight systems mature, the ACE reactor could provide an economical source of oxygen. In addition, the innovative electric resistance heaters developed for the ACE reactor could have a significant commercial market as the first high-temperature heating elements that can operate in oxidizing, reducing, and/or vacuum environments.

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